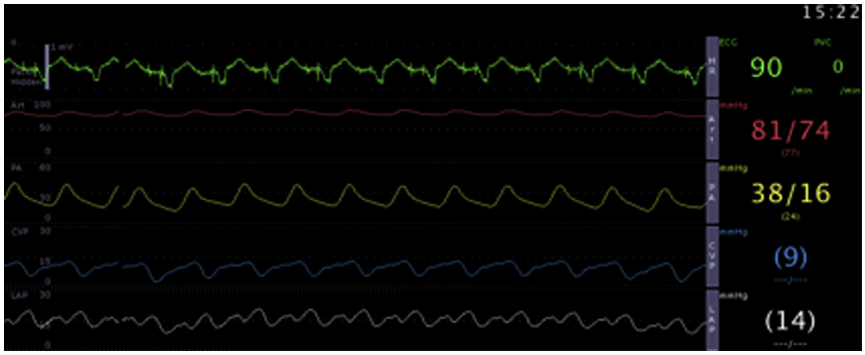


**FIGURE 6.** Left atrial line waveform (*bottom, white*).

temporary increase in HeartMate II device flows to decrease LA pressure and minimize bleeding into the pericardial cavity. Early in our series, we had the tip of the catheter dislodged in the pericardial cavity in 2 patients and 1 patient had a suction event after pre-pull HeartMate II device speed adjustment emptied the LV. After these initial complications, we used guide catheters to prevent dislodgement of the sensor tip. No bleeding or systemic embolic complications related to this LA monitoring system have been noted in our series.

## CONCLUSIONS

Our off-label LA pressure monitoring system using a Codman Microsensor offers safe and reliable results with minimal or no complications and should be implanted in all patients requiring direct LA pressure monitoring.

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# A technique for repair of partial anomalous pulmonary vein connection to the superior vena cava

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The repair of a partial anomalous pulmonary venous connection (PAPVC) to the high superior vena cava (SVC) was simplified by the surgical procedure reported by Warden et al[1] in 1984. They described a technique that consisted of dividing the SVC right above the anomalous pulmonary vein, oversewing the lower SVC end, connecting the SVC upper end to the right atrial appendage, and placing an intra-atrial patch to complete the pulmonary vein drainage to the left atrium through the atrial septal defect. This ingenious Warden procedure prevents damage to the sinus node and allows the involved anatomic structures to grow. However, this operation has a limitation for patients with a very high connection of the anomalous pulmonary vein to the SVC. In such situations, the caval division above the pulmonary vein entrance in the SVC

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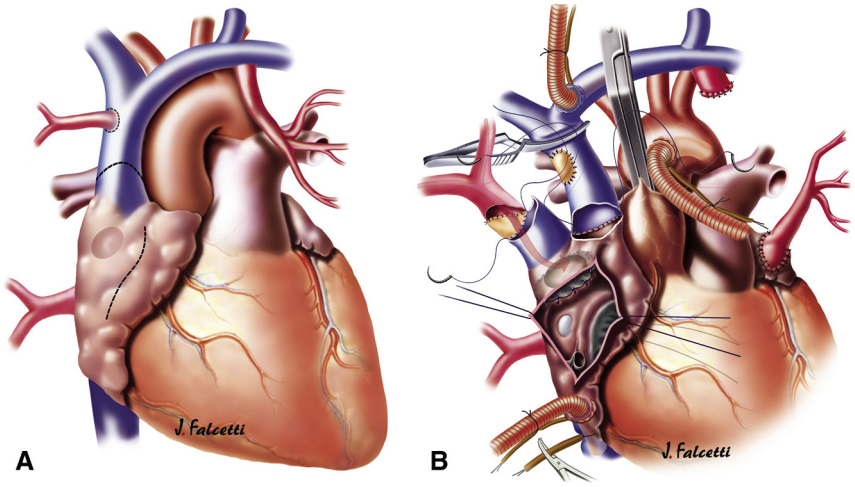


**FIGURE 1.** A, The abnormal connection between the right superior pulmonary vein (RSPV) and the superior vena cava (SVC) is very high. The sinus venosus atrial septal defect is shown by the transparency. The *dashed lines* indicate where to make the incision to separate the RSPV from the SVC, the SVC level of section, and the right atriotomy place. B, After separation of the RSPV from the SVC, the hole was closed with a fresh pericardial patch. Another in situ or free pericardial patch was used to enlarge the anastomotic mouth of the RSPV, which will be sutured to the atrial side of the sectioned SVC. A Dacron patch was sutured to the inferior edge of the enlarged atrial septal defect and upward, blocking the SVC orifice to direct the blood flow from the anomalous RSPV into the left atrium. Next, the superior end of the sectioned SVC was sutured to the right atrial appendage.

will result in a short upper SVC end that does not reach the right atrial appendage for a direct anastomosis. The objective of the present report was to describe a modification of the Warden procedure to repair such cases without the interposition of an artificial conduit between the SVC and the right atrial appendage.

## CLINICAL SUMMARY

A mildly symptomatic 10-year-old girl presented with a sinus venosus atrial septal defect, a very high PAPVC to the SVC, and an anomalous connection between the left superior pulmonary vein and proximal innominate vein (Figures 1, *A*, and 2, *A* and *B*). She was referred for surgical treatment, which was performed in January 2013, after the parents had provided informed consent.

## SURGICAL TECHNIQUE

A standard median sternotomy was performed to approach the right and left anomalous pulmonary vein connections. The SVC was mobilized toward the innominate vein, which was dissected out, exposing the anomalous connection of the left superior pulmonary vein to the proximal innominate vein and the right superior pulmonary vein (RSPV), entering the SVC very high, just after the right subclavian vein had merged with the right jugular vein. The azygos vein was divided. Cardiopulmonary bypass was established by placing a cannula in the ascending aorta for arterial perfusion, a venous cannula in the inferior vena cava, and a right-angle metal tip cannula for direct cannulation of the innominate vein. After cooling the patient to 28°C, aortic crossclamping and administration of blood cardioplegic solution, the left superior pulmonary vein was separated from the innominate vein and anastomosed to the left atrial appendage. The procedure to repair the right anomalous pulmonary vein connection is shown in Figure 1.

## RESULTS

The patient had an uneventful recovery, did not require a blood transfusion, and did not develop cardiac arrhythmia. The postoperative angiogram showed an unobstructed new right superior pulmonary vein pathway to the left atrium and SVC connection to the right atrial appendage (Figure 2, *C*).

## DISCUSSION

A very high PAPVC to the SVC is technically difficult to repair surgically. To solve this anatomic situation, Said and colleagues[2] have modified the Warden technique by inserting a short, ringed, artificial graft between the SVC and the right atrial appendage.[2] However, this procedure has the disadvantages of requiring anticoagulation and the possibility of graft overgrowth when used in children. Our surgical modification of the Warden procedure included SVC division below the anomalous RSPV entrance, separation of the RSPV from the SVC, and patch closure of the resulting hole, followed by downward mobilization of the RSPV for anastomosis to the caudal SVC end. The patch enlargement of the RSPV was necessary to match its size to the lower caval stump, without making it shorter. This surgical strategy seeks to retain the growing potential of the involved anatomic

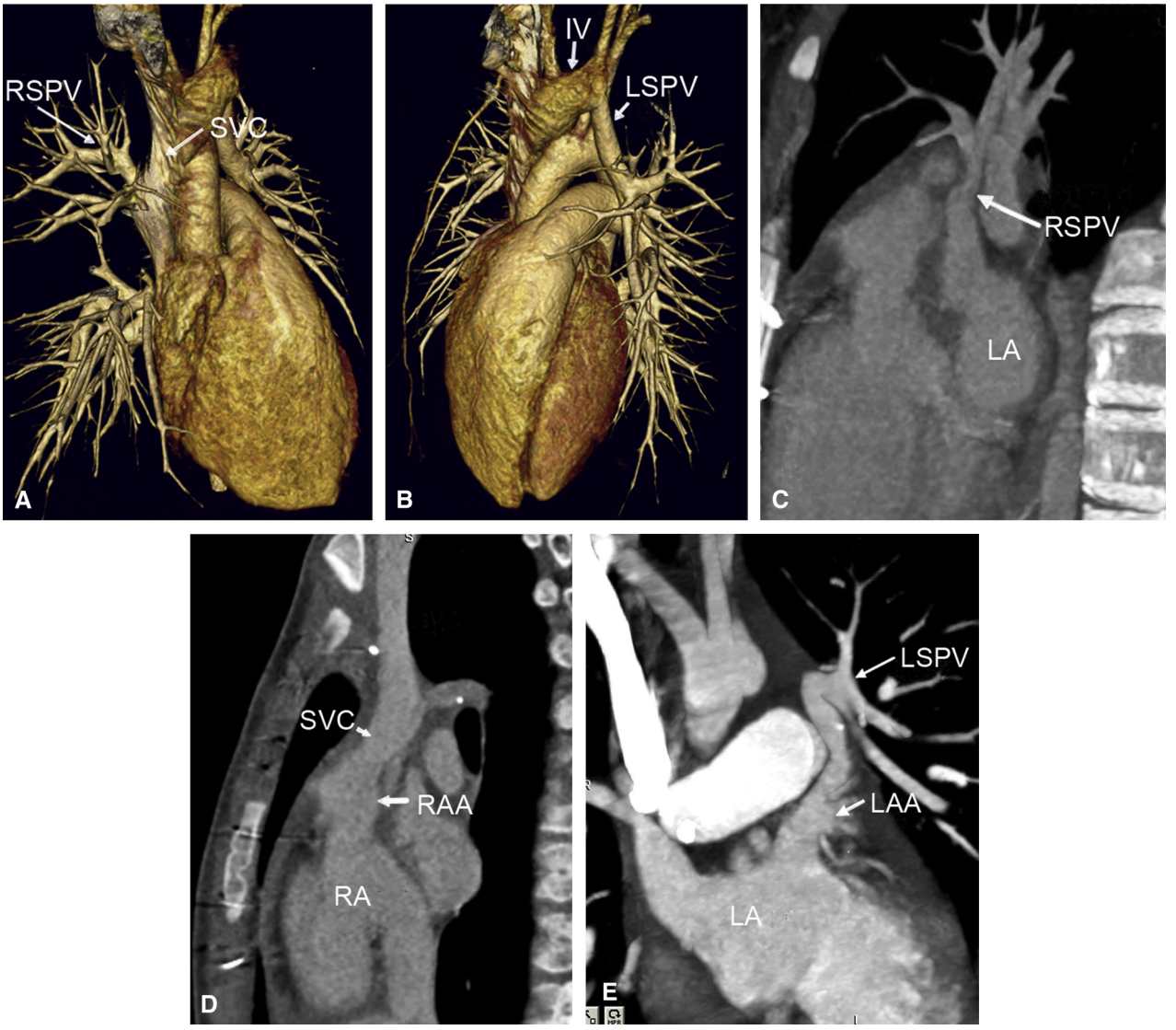


**FIGURE 2.** Angiographic computed tomography results. Preoperative angiographic view of (A), the right superior pulmonary vein (*RSPV*) connected very high to the superior vena cava (*SVC*) and (B), the left superior pulmonary vein (*LSPV*) connected to the innominate vein (*IV*). Postoperative angiogram of (C), the new connection between the RSPV and the left atrium (*LA*), (D), the SVC connection to the right atrial appendage (*RAA*), and (E), the connection of the left superior pulmonary vein to the left atrial appendage (*LAA*). *RA*, Right atrium.

structures, while protecting the sinus node region from trauma. Although our operative technique is more complex than the Warden operation, it has the same goal of not injuring the sinus node area. This concept of preventing cardiac arrhythmias by not cutting or suturing near the sinus node or its blood supply arteries has been supported by other publications of patients undergoing the Warden procedure.[3,4] The operation we have described could be useful when approaching young patients with a very high PAPVC to the SVC.

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